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SOIL, WATER, AND VEGETATION CONDITIONS IN SOUTH TEXAS

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16. Abstract

Statistically significant but different relationships between grain yield and plant parameters were obtained for drought-affected dryland than for irrigated sorghum. MSS CCT are not yet available for relating yield to LANDSAT spectral data.

Spectrophotometrically measured infinite reflectance (R_∞) of dead and live corn (Zea mays L.) were compared over the 0.5- to 2.5-µm waveband as a basis for distinguishing live and dead vegetation. Near infrared reflectance differences were greatest and should be detectable in satellite multispectral scanner data.

LANDSAT-1 MSS digital data for a December 11, 1973, overpass (scene I.D. 1506-16293) were used to estimate sugarcane acreage in Hidalgo County. The computer-aided estimate (22,100 acres) was 8% larger than the Texas Crop and Livestock Reporting Service estimate (20,500 acres). The hand mapped location of sugarcane fields agreed well with their location on the thematic map generated by the computer.

Field measurements made at .05 µm wavelength intervals over the range 0.5- to 2.45-µm on plots of stargrass receiving various rates of fertilizer show a high correlation between reflectance and grass yield.

17. Key Words (Selected by Author(s)) Crop discrimination; Ground truth; Acreage estimation; Range sites; Classification results; Biomass; Leaf reflectance.	18. Distribution Statement

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TYPE II QUARTERLY PROGRESS REPORT

July 13, 1975 to October 13, 1975

A. Problems:

The El Sauz ranch in Willacy County was to be a test site for the rangeland work of this contract since it had been soil mapped by the SCS and 17 range sites had been identified. However, the ranch changed hands since the proposal was submitted, and the new owner would not permit us to go onto the ranch. Therefore, it was necessary to find alternative ranch cooperators. The new cooperators are the Yturria ranches in Willacy and Kenedy Counties and the Port Mansfield Navigation District. These sites are adjacent (north and east) to the El Sauz Ranch, and many of the range sites are the same. Identification and characterization of typical range sites have been accomplished, and periodic biomass and other measurements have been taken routinely since June.

We had a 1° error in our site longitude in the "data products" section of our proposal that resulted in our being mailed standing order photoproducts for one orbit west of our test sites. The standing order has been corrected as of September.

Only two or three standing orders have been received due to cloud cover conditions during the spring and summer for both LANDSAT-1 and LANDSAT-2 overpass dates. We did have an overpass by LANDSAT-2 on April 2, 1975 (scene I.D. 2070-16203) under nearly clear conditions. CCT ordered for that scene on 7/28/75 were received 9/29/75.

A single 9.5-inch black-and-white positive transparency (band 6) was ordered 8/29/75 for the following LANDSAT-1 and LANDSAT-2 scenes. The transparencies will be used to determine cloud conditions, site coverage, and general atmospheric and ground conditions. Retrospective orders will be placed for the remaining photoproducts and for digital tapes of useful and needed scenes.

LANDSAT-1

Date	Scene I.D.	Orbit No.	Center coordinates	
			Lat.	Long.
3/24/75	1974-16142	13581	2559N	9807W
4/11/75	1992-16132	13832	2606N	9804W
5/17/75	5029-16113	14334	2558N	9807W
6/4/75	5046-16103	14585	2559N	9807N
7/10/75	5082-16083	15087	2605N	9800W
7/28/75	Not in catalog	15338	N	W

Note: Scanner off on 4/29/75 and 6/22/75, else would have ordered.

LANDSAT-2

Date	Scene I.D.	Orbit No.	Lat.	Long.
4/2/75	2070-16203	975	2603N	9747W
4/20/75	2088-16203	1226	2556N	9755W
5/8/75	2106-16200	1477	2715N	9729W
5/8/75	2106-16202	1477	2549N	9751W
5/26/75	2124-16202	1728	2554N	9751W
6/13/75[a]	Not in catalog	1979	N	W
7/1/75	2160-16204	2230	2554N	9759W
7/19/75	2178-16202	2481	2604N	9754W
8/6/75	2196-16195	2732	2559N	9752W

a/ Coverage map in customer catalog shows coverage stopped above Raymondville. It has been verified with the ASCS Laboratory at Salt Lake City that images for the two above scenes, not included in the catalog, do not exist.

B. Accomplishments:

Rangeland

Major range sites in Willacy and Kenedy Counties large enough to be discernible on LANDSAT-2 imagery have been selected representing both improved (brush controlled) and native conditions. They were botanically characterized, and herbaceous biomass measurements were made in late July and early August following heavy rains in June and July. Following heavy rains in late August and early September, the range was in flush condition again. The selected sites were again botanically characterized, and biomass measurements were taken in October. Thus, rangeland condition and composition have been determined following two rainy periods.

The range sites being studied are the deep sand, coastal sand, tight sandy loam, sandy mound, and salty flat. Two non-productive land use areas also included in this study are the duneland and tidal flat areas. These bare soil areas are adjacent to or intermingled in the rangeland areas. In addition to the native sites, improved sites including a deep sand and a tight sandy loam site on which the brush has been controlled and native herbaceous vegetation has re-established, and a tight sandy loam site on which the brush has been controlled and the range re-seeded to Aliciagrass, a new Bermudagrass variety, are being studied.

The botanical composition and herbaceous biomass production are quite variable among sites. Sites such as the tight sandy loam (native) and salty flat are low productivity sites, while the improved tight sandy loam and the re-seeded tight sandy loam are highly productive (Table 1). The duneland and tidal flat areas are nonproductive.

Table 1. Herbaceous biomass production for various range sites sampled in late July and early August 1975, following heavy rains in June and July.

Range site	Forage production
	lbs/acre
Tight sandy loam - native	251
Tight sandy loam - improved, re-established native grasses and herbs	1,235
Tight sandy loam - improved, re-seeded with Aliciagrass	2,093
Coastal sand - native	914
Sandy mound - native	*
Deep sand - native	757
Deep sand - improved, re-established native grasses and herbs	823
Salty flat	192

* This site was inaccessible due to high water.

Cropland

Ground truth data collection for spring and summer crops has terminated and data collection for fall and winter crops has started.

Statistical analyses (analysis of variance, correlation, regression) of spring and summer data are almost complete. Simple linear coefficients for correlations between leaf area index (LAI) and plant population, between LAI and percent vegetative cover, and between LAI and plant height were highly significant.

Multiple linear correlation coefficients among grain yield and LAI, percent cover, plant height, and plant population were significant for nonirrigated and highly significant for irrigated sorghum. Dryland sorghum experienced a drought; grain yields were only 1/3 to 1/2 of normal yields.

Of 197 data segments in Hidalgo County, 172 have been visited and the data are being punched on cards preparatory to storage on magnetic tape and disk files for further analysis and study in conjunction with LANDSAT-1 and LANDSAT-2 CCT digital counts (spectral responses).

Grass Reflectance and Green Biomass

Field measurements made with a spectroradiometer on plots of stargrass receiving various fertilizer rates showed a high correlation between percent reflectance and grass yield (Table 2). Reflectance measurements were made at 0.05-μm wavelength intervals over the range 0.50- to 2.45-μm shortly before the grass plots were sampled for yield measurements Correlation coefficients were calculated between fresh green weight yield and percent reflectance at each wavelength interval. Linear regression equations were calculated for each of these comparisons. Those wavelengths where absorption is a major factor in the reflectance curves were omitted in Table 2. The regression line slopes represent the average grams of yield change for each percent change in reflectance.

Table 2. Simple linear correlation coefficients, as well as the regression slope and percent of variation (r^2 x 100), between green biomass and percent reflectance of stargrass at 34 wavelengths.

Wavelength	Correlation between green biomass and reflectance	Slope of linear regression (Y=A+Bx)	Percent of variation attributable to green biomass
L, µm	r	B (gm/%)	r^2 x 100
0.50	.499	1328.	24.9
0.55	-.657	-1259.	43.1
0.60	-.868	-891.	75.3
0.65	-.942	-775.	88.7
0.70	-.932	-714.	86.9
0.75	+.925	+125.	85.6
0.80	.930	129.	86.5
0.85	.917	126.	84.1
0.90	.931	136.	86.7
0.95	.875	147.	76.6
1.00	.887	168.	78.7
1.05	.885	151.	78.3
1.10	.876	150.	76.7
1.15	.855	188.	73.1
1.20	.705	257.	49.7
1.25	.681	240.	46.3
1.30	.651	220.	42.4
1.50	-.803	-327.	64.5
1.55	-.812	-362.	65.9
1.60	-.725	-329.	52.6
1.65	-.637	-288.	40.6
1.70	-.642	-274.	41.2
1.75	-.661	-266.	43.7
1.80	-.514	-162.	26.4
2.00	-.850	-370.	72.2
2.05	-.914	-349.	83.5
2.10	-.866	-360.	75.0
2.15	-.806	-316.	65.0
2.20	-.780	-310.	51.8
2.25	-.720	-352.	51.8
2.30	-.758	-345.	57.4
2.35	-.792	-384.	61.1
2.40	-.707	-289.	50.0
2.45	-.498	-283.	24.8

Dead vs Live Vegetation Reflectance

A paper entitled "Infinite Reflectance of Dead Compared With Live Vegetation" has been prepared by H. W. Gausman, R. R. Rodriguez, and A. J. Richardson. The Abstract follows; the entire manuscript is appended:

To distinguish dead from live vegetation, spectrophotometrically measured infinite reflectance (R_∞) of dead and live corn (*Zea mays* L.) leaves were compared over the 0.5- to 2.5-μm waveband. Live leaf R_∞ was essentially attained by stacking two leaves for the 0.50- to 0.75-μm waveband (chlorophyll absorption region), eight leaves for the 0.75- to 1.35-μm waveband (near-infrared region), and three leaves for the 1.35- to 2.5-μm waveband (water absorption region). Dead leaf R_∞ was reached over the entire 0.5- to 2.5-μm waveband by stacking only two or three leaves. Thus, aircraft and spacecraft reflectance measuring techniques probably can not distinguish density differences of dead vegetation, but they should distinguish density differences of live vegetation. Near-infrared reflectance differences between dead and live vegetation also should be detectable with satellite multispectral scanner data.

Such findings have application in assessing soil erosion by wind and water.

LANDSAT Computer-aided Survey System

The software modifications and development are about 80% completed for the up-dated, computer-aided LANDSAT crop and soil survey system mentioned in the Quarterly Progress Report for the period April 13, 1975 to July 13, 1975. Remaining work includes development of a LANDSAT multispectral scanner (MSS) digital data banding correction process and modification of existing programs for data summary of field and segment secondary computer compatible tapes (CCT). The preprocessing operations for correlating earth coordinates with CCT coordinates are fully developed and in operation.

The rapidly expanding Rio Grande Valley sugar industry is making a major impact on the economy of the area, so an inventory of this crop is timely. A LANDSAT-1 overpass on December 11, 1973 (Scene I.D. 1506-16293) was used to estimate sugarcane acreage in Hidalgo County using LANDSAT digital data in the Weslaco computer-aided survey system.

Digital training data from LANDSAT-1 CCT were selected from representative crop, soil, and water areas in Hidalgo County for five land use categories: sugarcane, McAllen-Brennan soil association, Harlingen-Benito soil association, other vegetation (citrus and rangeland), and water. All pixels of the county were classified by a maximum likelihood ratio algorithm. A ground truth map showing the distribution of sugarcane fields in the county (Figure 1) and the reported sugarcane acreage from the "1974 Texas Field Crop Statistics" report compiled by the Texas Crop and Livestock Reporting Service were used to test the validity of the LANDSAT computer-aided sugarcane acreage inventory.

The computer acreage estimate (Table 3), developed during the computer-aided survey was 22,100 acres compared with the Texas Crop and Livestock Reporting Service estimate of 20,500 acres, a gross overestimation of 8 percent. However, some sugarcane fields were harvested before the December 11, 1973 overpass, a Type I error that should have resulted in an under prediction of acreage. The computer falsely counted some areas in the county as sugarcane since they had spectral characteristics of sugarcane, a Type II error that should have resulted in an overestimation of sugarcane acreage. The overall result was a cancellation of errors that yielded a sugarcane acreage estimate close to the reported sugarcane acreage estimate.

Information currently available does not permit the magnitude of these Type I and II errors to be measured, but comparison of location of sugarcane fields in Hidalgo County (Fig. 1) with the sugarcane thematic map (Fig. 2) generated by the computer suggests that the errors are small. Many of the sugarcane fields marked on the county ground truth map (dark areas) can be identified on the county computer generated thematic map (darkest appearing line printer symbols). Harvested sugarcane fields appear as McAllen-Brennan soil association (/) or as Harlingen-Benito soil association (-). One area falsely identified as sugarcane on the computer generated thematic map appears northeast of Delta Lake (.). Citrus and rangeland are the blank areas of the thematic map. Thus, computer-aided surveys using LANDSAT MSS data may be useful for rapid inventory of sugarcane acreage.

Table 3. Comparison of computer sugarcane estimated acreage to ground truth estimated acreage (Texas Crop and Livestock Reporting Service) within Hidalgo County for the 1973 to 1974 growing season. Computer acreage estimates for soil, water, and other categories are also given although no other reported estimates are available for comparison. Computer estimates are based on a December 11, 1973 LANDSAT-1 overpass.

Category	LANDSAT estimate (acres)	Texas Crop and Livestock Reporting Service estimate (acres)
Sugarcane	22,127	20,359
McAllen-Brennan soil	174,112	---
Harlingen-Benito soil	115,237	---
Water	9,900	---
Other vegetation	702,204	---
Total	1,023,580	---

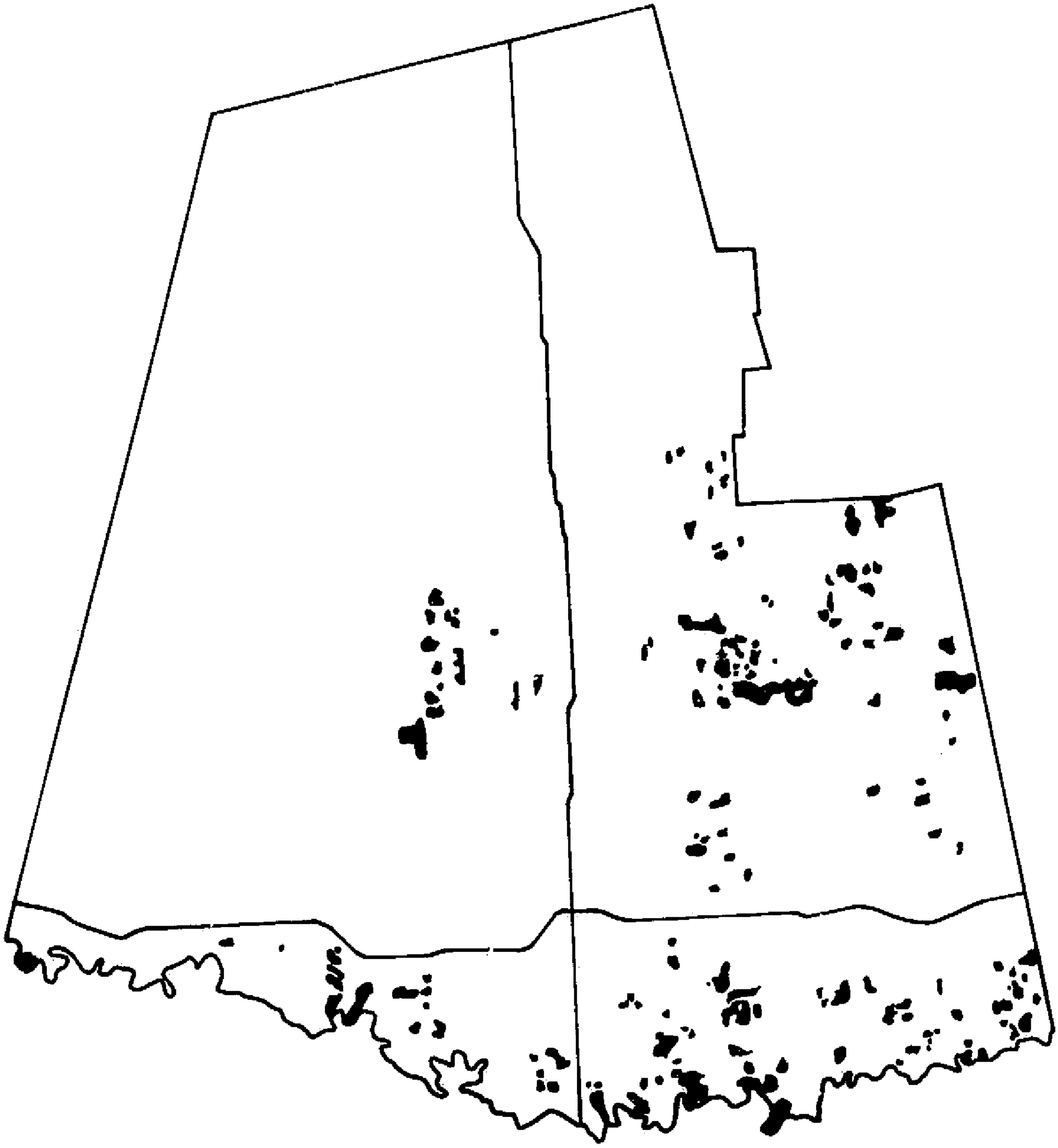

Figure 1. Ground truth map showing distribution of sugarcane in Hidalgo County for the 1973 to 1974 sugarcane growing season.

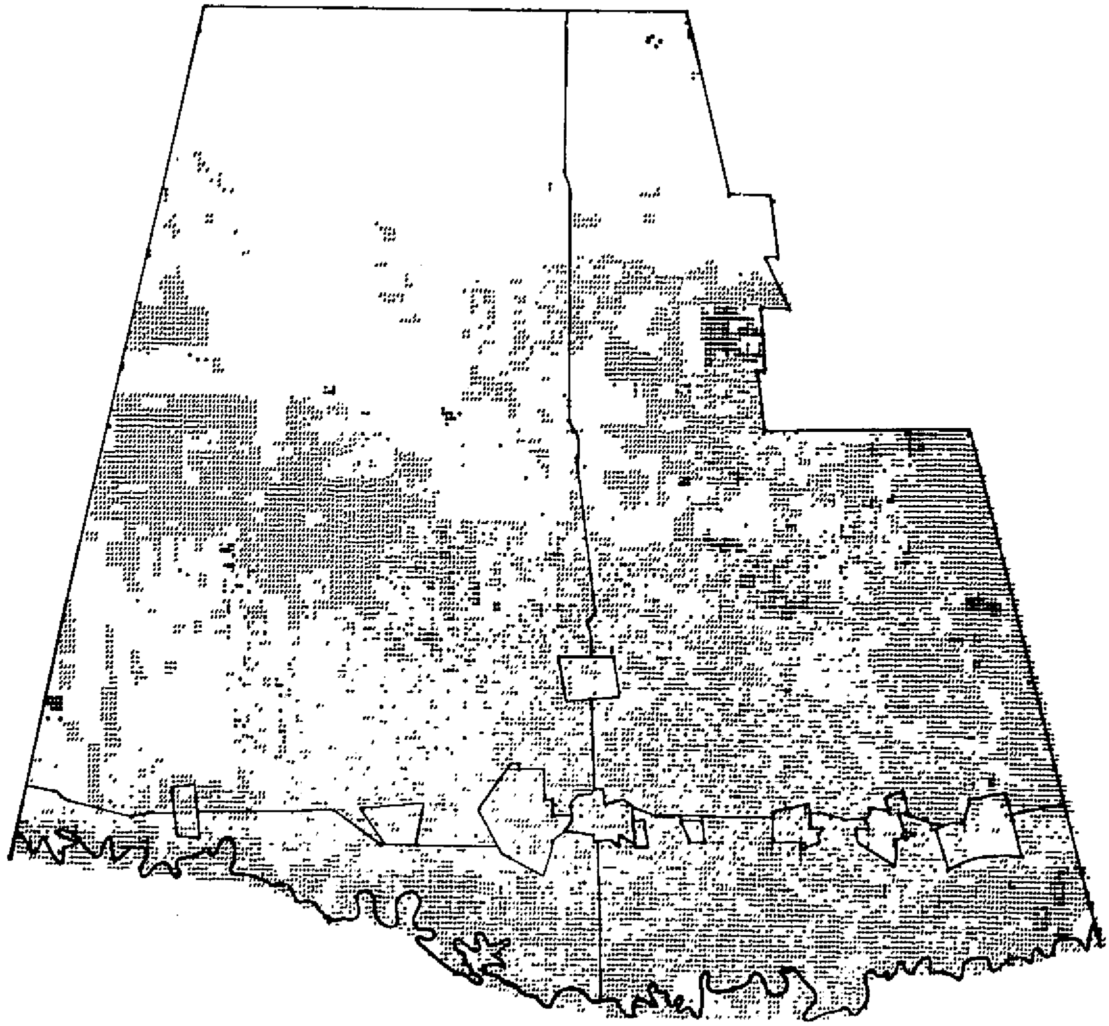

Figure 2. Computer generated thematic map showing sugarcane as darkest appearing line printer symbols (M overprinted W) and McAllen-Brennan soil association, Harlingen-Benito soil association, other vegetation, and water as the lighter appearing line printer symbols "/", "-", "space", and ".", respectively, to visually orient sugarcane field locations within the county. Survey results are based on a December 11, 1973 LANDSAT-1 overpass using bands 5, 6, and 7.

C. Significant Results:

To distinguish dead from live vegetation, spectrophotometrically measured infinite reflectance (R_∞) of dead and live corn (Zea mays L.) leaves were compared over the 0.5- to 2.5-μm waveband. Dead leaf R_∞ was reached over the entire 0.5- to 2.5-μm waveband by stacking only two to three leaves. Live leaf R_∞ was attained by stacking two leaves for the 0.50- to 0.75-μm waveband (chlorophyll absorption region), eight leaves for the 0.75- to 1.35-μm waveband (near-infrared region), and three leaves for the 1.35- to 2.5-μm waveband (water absorption region). Thus near infrared reflectance differences between dead and live vegetation should be detectable with satellite multispectral scanner data. The application of such work is in relating plant residue and vegetative cover conditions to soil erosion by wind and water.

LANDSAT-1 MSS digital data for a December 11, 1973, overpass (Scene I.D. 1506-16293) were used to estimate the sugarcane acreage in Hidalgo County. The computer-aided estimate was 22,100 acres compared with the Texas Crop and Livestock Reporting Service estimate of 20,500 acres for the 1973-'74 crop year. Although there were errors of omission from harvested fields that were identified as bare soil and some citrus and native vegetation that were mistakenly identified as sugarcane, the mapped location of sugarcane fields in the county compared favorably with their location on the thematic map generated by the computer. The fall of the year, before significant acreage of sugarcane is harvested (harvest begins in October and lasts through March), is a good time to make such a survey since other plants except citrus and native trees have a less dense canopy than sugarcane, hence dissimilar spectral signatures.

D. Publications:

Gausman, H. W., A. H. Gerbermann, C. L. Wiegand, R. W. Leamer, R. R. Rodriguez, and J. R. Noriega. Reflectance differences between crop residues and bare soils. Soil Sci. Soc. Amer. Proc. 39:752-755. 1975.

Gausman, H. W., R. R. Rodriguez, and A. J. Richardson. Infinite reflectance of dead compared with live vegetation. Accepted for publication by Agron. J.

Richardson, A. J., C. L. Wiegand, H. W. Gausman, J. A. Cuellar, and A. H. Gerbermann. Plant, soil, and shadow reflectance components of row crops. Accepted for publication by Photogram. Eng. and Remote Sensing.

Wiegand, C. L., A. J. Richardson, A. H. Gerbermann, H. W. Gausman, and J. A. Cuellar. Relation of ERTS-1 reflectance to crop parameters, and an introduction to a reflectance model. Agron. Abstracts, p. 16, 1975.

E. Recommendations:

None.

F. Funds Expended:

The following statement of expenditures covers the period January 13, 1975 to the date indicated for each item.

	FY '75 (1/13/75-6/30/75)	FY '76		Cumulative
Salaries	$ 6,010.	$ 9,850.	(7/1-9/13)	$15,860.
Supplies and Equipment	15,821.	13,903.	(7/1-10/10)	29,724.
Local Flying Service	589.	1,482.	(7/1-9/30)	2,071.
G & A (18%)	6,560.	12,600.	(for yr.)	19,160.
	$28,980.	$37,835.		$66,815.

APPENDIX A

INFINITE REFLECTANCE OF DEAD COMPARED WITH LIVE VEGETATION[1]

H. W. Gausman, R. R. Rodriguez, and A. J. Richardson[2]

[1] Soil and Water Conservation Research, Southern Region, Agricultural Research Service, USDA, Weslaco, Texas. This study was supported in part by the National Aeronautics and Space Administration under Contract No. S-70251-AG, Task 3.

[2] Plant Physiologist, Biological Technician Plants, and Physicist, respectively, USDA, Weslaco, TX 78596.

Crops residues on the soil surface reduce wind and water erosion, and vast acreages need to be watched carefully, particularly in highly erodable sandy regions. Thus, research has been conducted to use data provided by the first Earth Resources Technology Satellite (LANDSAT-1) to determine the presence of crop residues (Gausman et al., 1975).

The reflectance of green crops viewed against a soil background increases as number of plant leaf layers in the canopy increases until a stable reflectance, called "infinite reflectance" (R_∞) is reached (Allen and Richardson, 1968). In the visible and 1.5- to 2.5-μm waveband, R_∞ is attained as the plants reach a leaf area index (LAI) of 2. Leaf area index measured in the field is the ratio of total leaf area of plants to ground area covered by plants. The field definition of LAI is simulated in the laboratory by stacking leaf layers. In the near-infrared region (0.75 to 1.35 μm), an LAI of about 8 is needed to reach R_∞ because of the transparency of the leaves at this wavelength band.

For dead vegetation, R_∞ is apparently attained much sooner than for green crops. Tucker, Miller, and Pearson (1973) reported that increasing amounts of standing dead vegetation did not affect reflectance in the near-infrared region. Gausman et al. (1975) found that present reflectance measuring techniques are unable to distinguish quantities of crop residue from the soil, and better parameters are needed to describe crop residues.

This paper compares the spectrophotometrically measured R_∞ of dead and live corn leaves over the 0.5- to 2.5-μm waveband. An understanding of differences in R_∞ values between dead and live vegetation at different wavelengths should be useful in distinguishing dead from green vegetation by remote sensing techniques.

MATERIALS AND METHODS

One hundred and twenty leaves, sixth down from the plant apices, were randomly collected from 46-day old field-grown white corn (Zea mays L.; cultivar Harper W-45) plants that were about 1.4 m tall. The leaves were wrapped with plastic wrap to reduce moisture loss and stored and transported to the laboratory on ice. Then, a 10.3-cm square section, 31-cm from the leaf apex, was removed from each leaf. The 120 sections were mixed, and 60 were selected for spectrophotometric reflectance measurements on live tissue. The remaining 60 were laid on a white cardboard and held in place with a coarse screen and then placed on a flat roof for 36 days. The sections were turned once weekly. These sections will be referred to as "dead tissue."

A Beckman DK-2A Spectrophotometer[3], equipped with a reflectance attachment, was used to measure total reflectance on top (adaxial) surfaces of dead and live leaf sections. Measurements on the live tissue were made within 3 hr after leaves were collected. For both dead and live leaf sections, reflectance measurements were made for five replications of a single leaf section and for sections stacked two, three, four, five, six, seven, and eight at a time over the spectrophotometer's port. Of the 60 sections, 40 (eight sections for each of five replications) were used for both dead and live tissue reflectance measurements. Data were recorded at discrete 0.05-μm intervals over the continuously measured 0.5- to 2.5-μm waveband. Data were corrected for decay of the $BaSO_4$ standard to give absolute radiometric data (Allen and Richardson, 1972).

Water contents of the 40 dead and 40 live leaf sections were determined on a dry-weight basis; samples were oven dried at 68C for 72 hr and cooled in a desiccator before weighing.

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[3] Mention of company name or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the U. S. Department of Agriculture over others that may be commercially available.

RESULTS AND DISCUSSION

The average percent moisture contents were 3.2 ± 0.9 (S.D.) and 76.4 ± 1.9 for dead and live corn leaf sections, respectively. The average leaf water content range for replications of single leaf measurements was associated with an average 0.6% and 0.9% variation in reflectance at the 1.45-μm water absorption band for dead and live leaves, respectively.

Figure 1 charts the spectrophotometrically measured reflectance of single and stacked dead (upper graph) and live (lower graph) corn leaves over the 0.5- to 2.5-μm waveband. For live leaves, R_∞ was essentially attained by stacking two leaves for the 0.5- to 0.75-μm waveband (chlorophyll absorption region), eight leaves for the 0.75- to 1.35-μm waveband (near-infrared region), and three leaves for the 1.35- to 2.5-μm waveband (water absorption region). For dead leaves, R_∞ was essentially attained by stacking only two or three leaves over the entire 0.5- to 2.5-μm waveband. Similar results, not included, were obtained for dead avocado and orange leaves.

Reflectance differences between stacked dead and live leaves can be explained by fundamental histological and optical properties. Reflectance and transmittance of a plant leaf in the near-infrared region (0.75 to 1.35 μm) have been explained on the basis of critical (Fresnel) reflection of light at the cell wall-air interface of the spongy mesophyll tissue (Willstätter and Stoll, 1918; Knipling, 1970; Woolley, 1971; Gausman and Allen, 1973; Sinclair, Schreiber, and Hoffer, 1973). Reflectance in the near-infrared region increased as number of air spaces in a leaf mesophyll increased. (Chlorophyll and water absorption affects reflectance principally in the 0.5- to 0.75-μm and 1.35- to 2.5-μm wavebands for live and normal leaves, respectively.) Dehydration collapses tissue so that the number of air voids increase[4]. Thus, dead leaves have more air-cell interfaces than live leaves.

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[4] Sinclair, T. R. 1968. Pathway of solar radiation through leaves. M. S. Thesis, Purdue University Library, Lafayette, IN. 179 pp.

Dead and live corn leaf sections differed most in number of stacked leaves required to attain R_∞ in the near-infrared region (0.75 to 1.35 μm). In this waveband, the reflectance of live vegetation will increase as leaf layers in a plant canopy increase until R_∞ is reached (Allen and Richardson, 1968); therefore, live vegetation density can be deduced from satellite multispectral scanner data (Wiegand et al., 1974). For dead vegetation, however, R_∞ is reached with fewer leaf layers and at a lower reflectance level than for live vegetation in the near-infrared region. Thus, increasing the amounts of dead vegetation does not affect reflectance in the near-infrared region of the spectrum, and present aircraft and spacecraft reflectance measuring techniques probably cannot distinguish differences in density of dead vegetation. However, differences in R_∞ between dead and live vegetation in the near-infrared region should be useful in distinguishing dead from live vegetation in remote sensing applications.

LITERATURE CITED

Allen, W. A., and A. J. Richardson. 1968. Interaction of light with a plant canopy. J. Opt. Soc. Am. 58:1023-1028.

Allen, W. A., and A. J. Richardson. 1972. Calibration of a laboratory spectrophotometer for specular light by means of stacked glass plates. Rev. Sci. Instrum. 42:1813-1817.

Gausman, H. W., and W. A. Allen. 1973. Optical parameters of leaves of 30 plant species. Plant Physiol. 52:57-62.

Gausman, H. W., A. H. Gerbermann, C. L. Wiegand, R. W. Leamer, R. R. Rodriguez, and J. R. Noriega. 1975. Reflectance differences between crop residues and bare soils. Soil Sci. Soc. Amer. Proc. 39:752-755.

Knipling, E. B. 1970. Physical and physiological basis for the reflectance of visible and near-infrared radiation from vegetation. Remote Sens. Environ. 1:155-159.

Sinclair, T. R., M. M. Schreiber, and R. M. Hoffer. 1973. Diffuse reflectance hypothesis for the pathway of solar radiation through leaves. Agron. J. 65:276-283.

Tucker, C. J., L. D. Miller, and R. L. Pearson. 1973. Measurement of the combined effect of green biomass, chlorophyll, and leaf water on canopy spectroreflectance of the shortgrass prairie. Remote Sensing of Earth Resources 2:601-627

Wiegand, C. L., H. W. Gausman, J. A. Cuellar, A. H. Gerbermann, and A. J. Richardson. 1974. Vegetation density as deduced from ERTS-1 MSS response. Proc. 3rd ERTS-1 Symposium, Vol. I, Section A, NASA SP-351. U.S. Govt. Printing Ofc., Washington, DC pp. 93-116.

Willstätter, R., and A. Stoll. 1918. Untersuchungen über die Assimilation der Kohlensäure. Springer-Verlag, Berlin. p. 122.

Woolley, J. T. 1971. Reflectance and transmittance of light by leaves. Plant Physiol. 47:656-662.

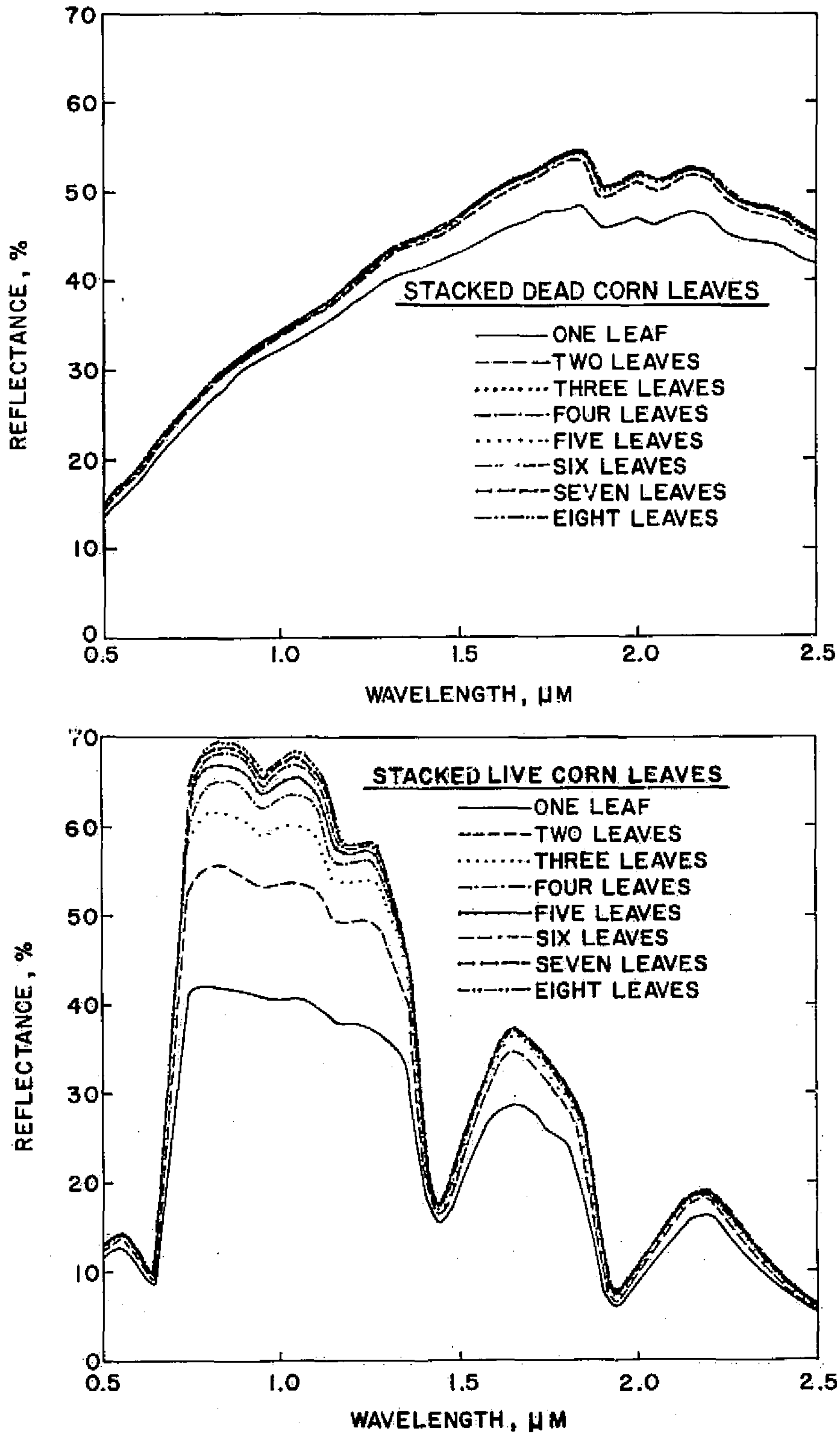

Fig. 1. Spectrophotometrically measured reflectance of single and stacked dead (upper graph) and live (lower graph) corn leaves over the 0.5- to 2.5-μm waveband.